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Full Length Article

Qualitative Analysis of Wheat Grain Damage during Harvesting with John Deere Combine Harvester

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ABSTRACT

Effects of forward speed, cylinder rotation and clearance between combine's cylinder and concave on wheat kernel breakage and seed germination were studied through analysis of variance. Three levels of adjustments for each of the variables, namely 1.2, 1.8 and 2.5 km h^{-1} for forward speed, 800, 900, 1000 rpm for cylinder rotation and 15, 20 and 25 mm for the clearance between cylinder and concave were constituted the variables. Results indicated an increase in kernel breakage and a decrease in seed germination due to decrease in forward speed, increase in cylinder rotation and decrease in clearance between cylinder and concave. The interaction between forward speed and cylinder rotation indicated a least kernel breakage of 5.47% along with the most seed germination of 96.61% arising from a forward speed of 1.8 km h^{-1} together with cylinder rotation of 800 rpm. Also, an interaction between cylinder rotation and concave clearance indicated a least kernel breakage of 5.38% at 900 rpm and 25 mm, respectively. A maximum seed germination of 96.58% was observed for the same above figures of cylinder rotation and clearance between cylinder and concave. Interactions between other combinations were non-significant. The most suitable adjustments for 955 model John Deere combine in the studied area would be 800 and/or 900 rpm, 1.8 km h^{-1} and 25 mm for cylinder rotation, forward speed and cylinder concave clearance, respectively.

Key Words: Wheat; Combine harvesting; Loss; Breakage; Germination

INTRODUCTION

Wheat is considered as the most important crop in Iran. It plays a major role as food for people. Wheat production is accompanied by major losses in Iran. Factors causing these losses have been known, but they have not been quantitatively evaluated. A majority of losses occur during harvest from combine harvesting. Timely operation, separation of grain from materials other than grain (MOG) with a least amount of loss and preservation of crop quality are some factors to which full attention must be paid in a good an efficient harvest. In recent years, a lot of works have been done on how to reduce grain losses during harvesting (Mohtasebi *et al.*, 2006). There are however, other losses such as those arise from damage to quality and the breakage of seed, which are also needed to be considered. For example, the breakage of grain will adversely affect seed germination, storage capacity, grain processing operations and final price of the product.

Mansoori and Minaee (2003) determined the effect of cylinder rotational seed and cylinder concave clearance on losses in the threshing unit. The authors found that an increase in cylinder concave clearance results in less breakage of grain. Arvinder *et al.* (2001) studied the effect of grain moisture, cylinder speed and feeding rate on mechanical damage inflicted upon the grain during combine harvesting as well as on seed germination. Dreszer and Gieroba (1999) carried out experiments to determine the mechanical damages introduced into several kinds of grains during harvest by multi-drum combines. Gill *et al.* (2002) tried to determine combine's thresher unit performance by considering the different factors effective in efficient wheat combine harvesting. Kowalczuk (1999) presented data obtained from combine harvesting of soybean in different regions in Poland. Santokh *et al.* (2002) evaluated field performance in combine harvesting of rice. Tahir *et al.* (2003), while experimenting on a denominator model of Class combine in Pakistan reported an average grain loss of 1.25%. Singh *et al.* (2002) investigated the effect of crop and machine parameters on threshing effectiveness and seed quality of soybean. They determined the external damage inflicted on the grain by finding the weight of broken grains in specified samples. They found that external damage increased with increase in cylinder speed at all moisture levels and variations in cylinder speed had little effect on germination rate. Investigations carried out by Kirkkari *et al.* (2001) in Finland on rye grain mechanical damage during threshing indicated an increase in germination rate followed by a decrease in cylinder speed. Kumar and Goss (2000) used data obtained from 224 field experiments to present models for combine performance. Model presented for broken seeds indicated significant correlation between

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cylinder speed and seed breakage. They found that an increase from 6 to 9% in broken seeds could be observed by an increase in cylinder speed from 20 to 25 m sec^{-1}. Andrews *et al*. (1993) in Philippine studied the effects of operational parameters in rice combine harvesting on crop quality and losses. It was demonstrated that feeding rate is the determining factor in rates of loss.

The objective of this study was to investigate effects of forward speed, cylinder speed and clearance between cylinder and concave on seed breakage and germination. The experiments are conducted during 2005 wheat harvest period by a model 955 John Deere combine harvester on the experimental farm of University of Tehran at Karaj.

MATERIALS AND METHODS

The experiments were carried out based on a factorial statistical design. Nine treatments in the form of randomized complete block design with 3 replications and in total, 27 cases were considered ($3 \times 3 \times 3$). Experiments were conducted in Karaj, while harvesting the wheat crop with a model 955 John Deere combine. Forward speeds of 1.2, 1.8 and 2.5 km h^{-1}, cylinder rotations of 800, 900 and 1000 rpm and cylinder concave clearance at three levels of 15, 20 and 25 mm constituted the variables. The width of the 4.5 × 40 m blocks was taken as a multiple of combine cutting width. Pickets were used to stake and mark the blocks. Clearance between cylinder and concave as well as cylinder rotational speeds were adjusted prior to the start of the experiment. Forward speed was adjusted along the first 30 m length of the harvest plot to the desired predetermined speed. Then, after the combine had reached its predetermined steady forward speed, wheat samples were taken from storage tank in separated tagged sacks.

Grain moisture content, as determined by a moisture meter (OGA model TA-5) was 12 – 14%. Cylinder rotational speed had been adjusted, while using a digital speedometer (Lutron model DT-2236), while a chronometer was employed to adjust the forward speed. One hundred gram grain samples were taken from previously tagged sample sacks to determine the external damage inflicted upon the grain. The cracked or broken grains were carefully picked out to determine the percent external damage. In order to determine the internal damage inflicted upon the grain, germination rate had to be determined. Fifty seeds were taken from any one of the sample sacks to be grown in a germinator where light, temperature and moisture were readjusted and controlled.

Data obtained from field and laboratory experiments were analyzed with regard to grain crop quality loss. Once the variance analysis (ANOVA) of resulting data based on factorial design model between different levels of two main factors and interaction between them showed a significant difference, mean major effects of factors on observed characteristics and their interactions were classified through Duncan test ($p < 0.05$). The statistical analysis was performed by using MINITAB 13.0 software (http://www.minitab.com).

RESULTS AND DISCUSSION

Table I shows the effects of forward speed, cylinder rotational speed and cylinder concave clearance on seed breakage and germination rate as obtained through analysis of variance. As revealed by figures in the table, there exists a significant relationship (at different levels of probability) between grain breakage and seed germination rates and the following: forward speed; cylinder speed; cylinder concave clearance; reaction between forward and cylinder speeds; and reaction between cylinder speed and cylinder concave clearance. But no significant relationship was observed between grain breakage and germination rates and either the reaction between forward speed and cylinder concave clearance or the simultaneous effects of forward speed, cylinder rotational speed and cylinder concave clearance.

Results of comparison of means are shown in Table II. A minimum of seed breakage is observed at a forward speed of 2.5 km h^{-1}, while a maximum at 1.2 mm h^{-1}. Seed germination rate is least in the case of 1.2 km h^{-1} forward speed, whereas it being maximum when the forward speed is 2.5 km h^{-1}. Generally speaking, there is a trend of decrease in seed breakage (accompanied by increase in seed germination rate) as forward speed increases. This is in line with results reported by Arvinder *et al*. (2001) the explanation for which could be an increase in throughput. Throughput, particularly MOG causes the grain pass in between mattress like layers of MOG thus being to a lesser extent exposed to impacts coming from cylinder rotation as against concave.

A comparison of means (Table II) reveals the great effect of cylinder rotational speed on grain breakage and seed germination. A cylinder rotational speed of 800 rpm resulted in the least grain breakage and most seed germination, whereas the most grain breakage accompanied by least seed germination rate came from a cylinder rotational speed of 1000 rpm. The fact that increases in cylinder speed is accompanied by more grain mechanical damage is in accordance with results obtained by other research workers (Dreszer & Gieroba, 1999; Kirkkari *et al*., 2001; Santokh *et al*., 2002; Mansoori & Minaee, 2003; Tahir *et al*., 2003). It is also revealed (Table II) that an increase in cylinder concave clearance from 15 to 25 mm results in less grain breakage and more seed germination. This is also confirmed by work down by Dreszer and Gieroba (1999) and Kowalczuk (1999). Considering the fact that threshing is accomplished through the two processes of impact and the grain being rubbed in between plant part layers it becomes evident that either increase in cylinder speed or decrease in the clearance between the cylinder and concave would add to the mechanical damage inflicted upon the grain or seed. Our experimental results are indicative of this fact too. Interaction between forward and cylinder

Fig. 1. Interaction between forward speed and cylinder speed on wheat breakage

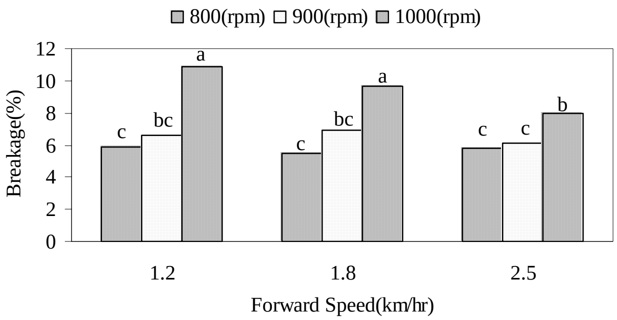


Fig. 2. Interaction between forward speed and cylinder speed on wheat germination

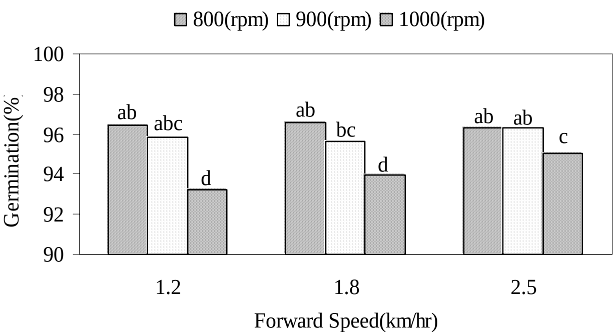


Fig. 3. Interaction between concave clearance and cylinder speed on wheat breakage

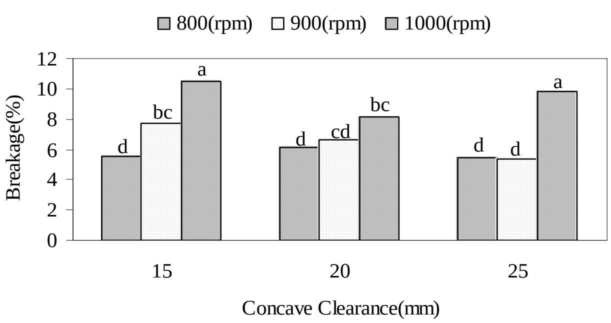
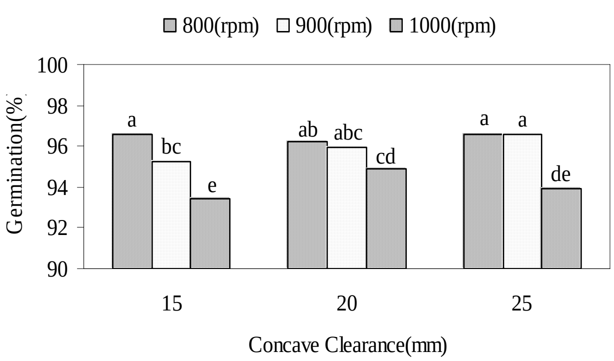


Fig. 4. Interaction between concave clearance and cylinder speed on wheat germination



rotational speed (See Fig. 1 & 2) indicates: (i) least breakage in grain occurs at forward speed of 1.8 km h^{-1} and 800 rpm cylinder speed and (ii) maximum breakage in seed occurs at forward speed of 1.2 km h^{-1} and 1000 rpm cylinder speed. As far as seed germination rates are concerned (Fig. 2) following conclusions can be made: (i) mximum seed germination occurs at forward speed of 1.8 km h^{-1} and 800 rpm cylinder speed and minimum seed germination occurs at forward speed of 1.2 km h^{-1} and 1000 rpm cylinder speed.

Table I. Analysis of variance of the effect of forward speed, cylinder rotational speed and cylinder concave clearance on seed breakage and germination rate

Source	DOF	Breakage	Germination
Replication	2	1.248	0.482
Forward Speed (FS)	2	9.106*	3.896**
Cylinder Speed (CS)	2	106.769**	42.214**
Concave Clearance (CC)	2	8.952*	3.311*
FS × CS	4	5.916*	2.528*
FS × CC	4	0.787	0.313
CS × CC	4	9.053**	3.031**
FS × CS × CC	8	1.282	0.390
Error	52	2.056	0.761
C.V.		19.76%	0.91%

*significant on the level of 5% **significant on the level of 1%

Table II. Comparison of Means (grain breakage & seed germination) through Duncan method and at different levels of variable factors

Factor	Breakage	Germination
Forward Speed (km/hr)		
1.2	7.778a	95.14b
1.8	7.356ab	95.40ab
2.5	6.630b	95.89a
Cylinder Speed (rpm)		
800	5.704c	96.45a
900	6.563b	95.91a
1000	9.496a	94.07b
Concave Clearance (mm)		
15	7.919a	95.07b
20	6.948b	95.68a
25	6.896b	95.68a

It becomes evident that with an increase in cylinder speed, the number of impacts between grain and cylinder increases; also damage incurred to grain becomes more contact between seed, cylinder and concave when there is less throughput of material in the threshing section of the combine. The interaction between cylinder speed and cylinder concave clearance, which is demonstrated in Fig. 3 indicates: A minimum of breakage in grain occurs at a cylinder speed of 900 rpm and a cylinder concave clearance of 25 mm, whereas a maximum of grain breakage is observed when the cylinder speed is 1000 rpm and cylinder concave clearance is chosen 15 mm.

As seed germination rate is concerned, it is revealed from Fig. 4 that: (i) maximum seed germination is resulted from an interaction between cylinder speed of 900 rpm and cylinder concave clearance of 25 mm and (ii) minimum of seed germination is obtained, when cylinder speed is 1000 rpm and cylinder concave clearance 15 mm.

A combination of increase in cylinder speed and decrease in the clearance between cylinder and concave as an interaction between the two variables indicates much breakage of seed and little seed germination. In fact, increase in cylinder speed results in progressive damage to the grain and seed (Srivastava *et al*., 2003).

CONCLUSION

Data obtained from field and laboratory experiments were analyzed with regard to grain crop quality loss. Effects of forward speed, cylinder rotation and clearance between combine's cylinder and concave on wheat kernel breakage and seed germination were studied through analysis of variance.

Results of the present investigation indicates that for model 955 John Deere combine harvester in Karaj area a combination of the following factors would render the proper adjustment of the combine for wheat harvest. A cylinder speed of 800 and/or 900 rpm, a cylinder concave clearance of 25 mm adjusted for a combine harvesting at a forward speed of 1.8 km h^{-1}. Since Mansouri and Minaee (2003) concluded that an increase in cylinder rotational speed from 750 to 950 rpm would double grain breakage, it is recommended that cylinder rotational speed of 800 rpm be chosen.

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